JC17 Rec'd PCT/PTO 11 MAY 2001

FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY 'S DOCKET NUMBER: 7418-2

U S APPLICATION NO (If known, see 37 CFR 1 5): 09/831665

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/GB99/03709	November 10, 1999	November 11, 1998

TITLE OF INVENTION: MONITORING SYSTEM

APPLICANT(S) FOR DO/EO/US: Brian S. Hoyle; Reginald Mann; Bruce D. Grieve; Trevor A. York

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [X] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [X] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [ ] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). (unsigned)
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [X] Other items or information:
    PCT Published Specification; International Preliminary Examination Report

"Express Mail" label number EL683238049US Date of Deposit May 11, 2001 I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR § 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231

Gail Mercer
Signature of Person Mailing Correspondence

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/831665	PCT/GB99/03709	7418-2

21. ☒ The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):

		CALCULATIONS PTO USE ONLY
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO	$1000.00	
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	$860.00	
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	$710.00	
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	$690.00	
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)	$100.00	
ENTER APPROPRIATE BASIC FEE AMOUNT =		$ 860.00
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	22 - 20 =	2	x $18.00	$ 36.00
Independent claims	2 - 3 =	0	x $80.00	$
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $270.00	$
TOTAL OF ABOVE CALCULATIONS =				$ 896.00
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.			+	$
SUBTOTAL =				$ 896.00
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$
TOTAL NATIONAL FEE =				$ 896.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property			+	$
TOTAL FEES ENCLOSED =				$ 896.00
			Amount to be refunded:	$
			charged:	$

a. ☒ A check in the amount of $ 896.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23-3030. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of:

Brian Hoyle et al.

Serial No. (unknown)

Filed May 11, 2001

MONITORING SYSTEM

US National Stage of PCT/GB99/03709
International Filing Date November 10, 1999)

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to the Assistant Commissioner for Patents, Washington, DC 20231 on May 11, 2001.

Thomas Q. Henry
Name of Registered Representative

Signature

May 11, 2001
Date of Signature

PRELIMINARY AMENDMENT

Hon. Assistant Commissioner of Patents

Washington, D.C. 20231

Sir:

Please enter the following Preliminary Amendment in the above-identified patent application. The Commissioner is hereby authorized to charge payment of any additional fees associated with this application or credit any overpayment to Deposit Account No. 23-3030.

IN THE CLAIMS

Please amend the claims as follows:

1. (Amended) A tomographic sensor array for mounting on a support within a vessel to enable conditions within the vessel remote from that support to be monitored, comprising a sheet [which may be mounted on a support within the vessel, the sheet] carrying an array of sensors and conductors connecting the sensors to at least one output through which signals may be transmitted which are representative of conditions [to which the sensors are exposed] within the vessel.

2. (Amended) A sensor array according to claim 1, wherein the sheet is laminar and the conductors are defined by conductive elements [tracks] deposited on an insulating substrate.

4. (Amended) A sensor array according to claim 2 [or 3], wherein the conductive elements [tracks] are covered by an electrically insulating layer.

6. (Amended) A sensor array according to [any one of] claim[s] 1 [to 5], wherein the sheet is flexible.

7. (Amended) A sensor array according to [any one of] claim[s] 1 [to 4], wherein the sheet comprises a series of sections which are interconnected such that at least some of the conductors extend across the interconnections between the sections.

8. (Amended) A system for monitoring conditions within a vessel a wall of which defines an enclosed space, comprising a sensor array in accordance with [any preceding] claim 1, wherein the sensors are distributed within the vessel, a first monitoring unit is located within the vessel and connected to each of the sensors, and a second monitoring unit is located outside the vessel, the first monitoring unit comprising means for converting sensor output signals into transmission signals which are transmissible through the vessel wall, and the second monitoring unit comprising means for detecting the transmission signals outside the vessel walls and deriving data representative of conditions within the vessel from the transmission signals.

11. (Amended) A system according to [any one of] claim[s] 8 [to 10], wherein the vessel incorporates a window, and the first monitoring unit is arranged to transmit optical transmission signals through the window to the second monitoring unit.

13. (Amended) A system according to claim 11 [or 12], wherein the optical transmission signals are infra-red signals.

14. (Amended) A system according to claim 8 [, 9 or 10], wherein the transmission signals are radio telemetry signals to which at least a part of the vessel wall is transparent.

18. (Amended) A system according to [any one of] claim[s] 15 [to 17], wherein the vessel incorporates a window, and the first monitoring unit is arranged to transmit optical transmission signals through the window to the second monitoring unit.

20. (Amended) A system according to claim 18 [or 19], wherein the optical transmission signals are infra-red signals.

21. (Amended) A system according to claim 15 [, 16 or 17], wherein the transmission signals are radio telemetry signals to which at least a part of the vessel wall is transparent.

22. (Amended) A system according to [any one of] claim[s] 15 [to 21], wherein the plurality of sensors are carried by a sheet which is secured on the inside face of the vessel wall, the sensors being connected to the first monitoring unit by conductive tracks formed on the sheet.

REMARKS

Consideration and allowance of the above application is respectfully requested.

Respectfully submitted,

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CLAIMS

1. A tomographic sensor array for mounting on a support within a vessel to enable conditions within the vessel remote from that support to be monitored, comprising a sheet carrying an array of sensors and conductors connecting the sensors to at least one output through which signals may be transmitted which are representative of conditions within the vessel.

2. A sensor array according to claim 1, wherein the sheet is laminar and the conductors are defined by conductive elements deposited on an insulating substrate.

3. A sensor array according to claim 1, wherein the sheet comprises interengaged elongate elements and the conductors are defined by conductive elements within the sheet, the conductive elements being supported by non-conductive elements within the sheet.

4. A sensor array according to claim 2, wherein the conductive elements are covered by an electrically insulating layer.

5. A sensor array according to claim 4, wherein the sensors are covered by the electrically insulating layer.

6. A sensor array according to claim 1, wherein the sheet is flexible.

7. A sensor array according to claim 1, wherein the sheet comprises a series of sections which are interconnected such that at least some of the conductors extend across the interconnections between the sections.

8. A system for monitoring conditions within a vessel a wall of which defines an enclosed space, comprising a sensor array in accordance claim 1, wherein the sensors are distributed

within the vessel, a first monitoring unit is located within the vessel and connected to each of the sensors, and a second monitoring unit is located outside the vessel, the first monitoring unit comprising means for converting sensor output signals into transmission signals which are transmissible through the vessel wall, and the second monitoring unit comprising means for detecting the transmission signals outside the vessel walls and deriving data representative of conditions within the vessel from the transmission signals.

9. A system according to claim 8, wherein means are provided for transmitting a power signal from outside the vessel to the first monitoring unit, the first monitoring unit comprising a detector arranged to detect the power signal and a power supply energised by the detected power signal.

10. A system according to claim 9, wherein the first monitoring unit comprises an antenna and an associated detector circuit tuned to a predetermined frequency, and a power signal is transmitted at the predetermined frequency.

11. A system according to claim 8, wherein the vessel incorporates a window, and the first monitoring unit is arranged to transmit optical transmission signals through the window to the second monitoring unit.

12. A system according to claim 11, wherein the first monitoring unit comprises a laser to generate the optical transmission signals.

13. A system according to claim 11, wherein the optical transmission signals are infra-red signals.

14. A system according to claim 8, wherein the transmission signals are radio telemetry signals to which at least a part of the vessel wall is transparent.

15. A system for monitoring conditions within a vessel a wall of which defines an enclosed space, comprising a plurality of sensors which in use are distributed within the vessel, a first monitoring unit located within the vessel and connected to each of the sensors, and a second

monitoring unit located outside the vessel, the first monitoring unit comprising means for converting sensor output signals into transmission signals which are transmissible through the vessel wall, and the second monitoring unit comprising means for detecting the transmission signals outside the vessel walls and deriving data representative of conditions within the vessel from the transmission signals.

16. A system according to claim 15, wherein means are provided for transmitting a power signal from outside the vessel to the first monitoring unit, the first monitoring unit comprising a detector arranged to detect the power signal and a power supply energised by the detected power signal.

17. A system according to claim 16, wherein the first monitoring unit comprises an antenna and an associated detector circuit tuned to a predetermined frequency, and a power signal is transmitted at the predetermined frequency.

18. A system according to claim 15, wherein the vessel incorporates a window, and the first monitoring unit is arranged to transmit optical transmission signals through the window to the second monitoring unit.

19. A system according to claim 18, wherein the first monitoring unit comprises a laser to generate the optical transmission signals.

20. A system according to claim 18, wherein the optical transmission signals are infra-red signals.

21. A system according to claim 15, wherein the transmission signals are radio telemetry signals to which at least a part of the vessel wall is transparent.

22. A system according to claim 15, wherein the plurality of sensors are carried by a sheet which is secured on the inside face of the vessel wall, the sensors being connected to the first monitoring unit by conductive tracks formed on the sheet.

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MONITORING SYSTEM

The present invention relates to a system for monitoring conditions within a vessel a wall of which defines an enclosed space and a sensor array for mounting within such a vessel.

Process tomography systems have been designed which can obtain valuable information about process conditions within vessels. In many situations however it is undesirable or unacceptable to penetrate a process vessel with cables to enable communication with sensors located within that vessel. Typical situations in which such restrictions apply are stirred tank reactors, fluidised beds, separators, cyclones, hydraulic and pneumatic conveyors, crystallisers and the like. Particularly in the case of bioreactors where sterility is an essential requirement, or pharmaceutical manufacturing where high integrity containment is required to guarantee an uncontaminated workplace and product, it is highly undesirable to have cables penetrating the walls of process vessels.

Typical tomography systems require a symmetrically distributed set of transducers from which sample data produces a set of "projections" through the process. These are then "reconstructed" to form an estimate of the cross-section interrogated by the sensor array in terms of the parameters sensed by the transducers. A range of process information may then be estimated, for example volume fraction in a flowing mixture, solids concentration in stirred reactors, density distribution in a product and the like.

Typically transducers are arranged either singly or in pairs or in groups to measure a range of parameters. Examples are electrical capacitance measuring systems, electrical resistance measuring systems, electromagnetic inductance measuring systems, acoustic and ultrasound reflection and transmission measuring systems, X-ray transmission measuring systems, and nuclear magnetic resonance measuring systems. In some processes two or more types of transducers are used in order to gain sensitivity to a range of materials within the process. Such applications are typically described as multi-modal tomography applications.

When a set of distributed transducers is used it is desirable that each transducer comes into close contact with or proximity to the process at a particular

geometric position. In a simple case each transducer may make such contact through a hole or opening formed at an appropriate location in a process vessel wall. Although such an approach is simple and direct and can readily be used for experimental purposes and may be viable in some practical circumstances, there are also many situations in which such penetration of a vessel wall is undesirable.

A further problem which can be encountered when seeking to fit tomographic sensors within a process vessel is that of appropriately positioning sensors on the inside of a process vessel wall, particularly in situations where it is inappropriate to make connections to the sensors directly through that wall. There are also applications in which the process vessel includes mechanical structures such as stirrers which prevent the surface mounting of bulky sensor assemblies on the process vessel wall. This makes it very difficult in many circumstances for tomography sensors to be retro-fitted to existing process vessels.

It is an object of the present invention to obviate or mitigate some or all of the problems outlined above.

The present invention provides a tomographic sensor array for mounting on a support within a vessel to enable conditions within the vessel remote from that support to be monitored, comprising a sheet carrying an array of sensors and conductors connecting the sensors to at least one output through which signals may be transmitted which are representative of conditions within the vessel.

The invention as defined in the preceding paragraph makes it possible to readily position sensors suitable for connection to a tomographic imaging system inside a process vessel without requiring significant clearance above the original process vessel wall surface, the relative positioning of different components of the sensor array being determined by the position of the components on the sheet.

The sheet may be a laminar construction with the conductors defined by conductive tracks or element deposited on an insulating substrate. Alternatively, the conductors may be defined by conductive elements supported within the sheet.

The conductive tracks or element may be covered with an electrically insulating layer, and the sensors may also be covered with the electrically insulating layer.

The sheet may be flexible.

The sheet may comprise a series of sections which are interconnected such that at least some of the conductive tracks extend across the interconnections between the sections

According to the present invention, there is also provided a system for monitoring conditions within a vessel a wall of which defines an enclosed space, comprising a plurality of sensors which in use are distributed within the vessel, a first monitoring unit located within the vessel and connected to each of the sensors, and a second monitoring unit located outside the vessel, the first monitoring unit comprising means for converting sensor output signals into transmission signals which are transmissible through the vessel wall, and the second monitoring unit comprising means for detecting the transmission signals outside the vessel wall and deriving data representative of conditions within the vessel from the transmission signals.

The invention as defined above makes it possible to avoid penetrating a process vessel wall with any cables even in the event that for example a tomographic sensing system incorporates a large number of sensors.

Preferably, means are provided for transmitting a power signal from outside the vessel to the first monitoring unit, the first monitoring unit comprising a detector arranged to detect the power signal and a power supply energised by the detected power signal.

The first monitoring unit may comprise an antenna and an associated detector circuit tuned to a predetermined frequency, and the power signal may be transmitted at the predetermined frequency.

The vessel may incorporate a window, and the first monitoring unit may be arranged to transmit optical transmission signals through the window to the second monitoring unit. The first monitoring unit may comprise a laser to generate the optical transmission signals. The optical signals may be infra-red signals.

The transmission signals may be radio telemetry signals to which at least a part of the vessel wall is transparent.

Referring to the accompanying drawings, an embodiment of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a vertical section through a process vessel incorporating a tomographic sensing system in accordance with the present invention;

Figure 2 is a plan view of a flexible sheet supporting a single electrode which is incorporated in the process vessel of Figure 1;

Figure 3 is a plan view of part of a further sheet carrying two electrodes also incorporated in the process vessel of Figure 1; and

Figure 4 is a section on the line 4-4 of Figure 2.

Referring to Figure 1, the illustrated process vessel has a wall 1 which completely encloses a space 2 within which for example a fermentation process is to be carried out. The vessel 1 has a steel wall in which a glass window 3 is provided, such windows being commonplace in process vessels to enable a visual inspection of the vessel contents. A first monitoring unit 4 is secured to the inside surface of the window 4 and a second monitoring unit 5 is secured to the outside surface of the window 4.

The first monitoring unit 4 is connected by a multi-way cable 6 to an electrode assembly which extends around the inner surface of the process vessel. The electrode assembly is made up of a series of units three of which are shown in Figure 1, that is units 7, 8 and 9. Each of the units is in the form of a flexible sheet adhered to the inner surface of the process vessel, the units being interconnected end to end. Figure 2 is a plan view of a sheet which can be used as the unit 7 or 8 in Figure 1. Figure 3 is a plan view of a sheet which can form the unit 9 of Figure 1. Figure 4 is a section through the sheet of Figure 2 in the direction of lines 4-4 in Figure 2.

Referring to Figures 2 and 4, the illustrated unit comprises a flexible electrically insulating substrate 10 upon which a copper electrode 11 and a series of conductive tracks 12 have been printed. An insulating layer 13 covers the conductive tracks 12 but does not cover the surface of the electrode 11 which is on the far side of the substrate 10 from the vessel wall 1. Accordingly resistance measurements may be made between any one electrode and one or more of the other electrodes in the array which are spaced around the process vessel. Each of the electrodes 11 is connected by a respective pair of tracks 12 to a terminal in a terminal array 14 provided on the electrode unit 9 (Figure 3). Each of those terminals is in turn connected by the cable 6 to the first monitoring unit 4.

Data derived from the electrodes 11 is optically coupled through the window 3 to the second monitoring device 5. The signals coupled through the window 3 may simply directly represent outputs derived from the electrodes 11, or those outputs may be processed in the first monitoring unit 4 before transmission to the second monitoring unit 5. Thus large amounts of data may be picked up by the electrode array and transmitted to the exterior of the process vessel without it being necessary for the process vessel wall to be penetrated in any way. In the event that the process vessel has to be sterilised between processing operations the electrode array is robust and can be readily cleaned.

Given that the electrodes 11 are mounted on an insulating substrate 10 which extends to a substantial distance away from the edges of the electrodes 11, electrical fields which can be generated within a process fluid within the process vessel are not shorted out to the process vessel wall at positions close to the electrodes. Thus electrical fields emanating from the electrodes 11 can extend a substantial distance into the body of the fluid contained by the vessel. Useful data can be obtained using conventional resistance tomography techniques.

Electrode arrays may be made up from a number of the individual units such as those illustrated in Figures 2 and 3 so as to make it possible to fit electrode arrays in process vessels of different sizes using essentially standard components. Individual electrode array units may be connected end to end using the end-connectors shown in Figures 2 and 3. The electrode arrays are thin and therefore can be readily shaped so as to be adhered closely to the walls of a process vessel, enabling their use in applications where the electrode arrays cannot project substantially from the internal wall of the vessel, for example when retro-fitting electrode arrays to vessels in which stirrers are provided which sweep across the inner surface of the vessel walls. It is a relatively easy matter to produce electrode assemblies with an installed thickness of less than one millimetre.

In the illustrated case, the electrodes 11 are not insulated from the process fluids. This is appropriate in the case of an electrode array used for resistance measurements. Other tomographic configurations are however possible, for example systems based on capacitance measurement. In the case of a system used for

capacitance measurements, the electrodes 11 may or may not be covered by the insulating layer 13.

Although in the illustrated case communication between the interior and exterior of the vessel is achieved through a window 3, it will be appreciated that the cable 6 could be fed through a suitably sealed opening in the process vessel wall, thereby enabling a direct connection to be made between the electrodes and the external monitoring unit 5.

In the case illustrated in Figure 1, it is necessary to energise the first monitoring unit 4. This could be achieved using a suitable battery-energised power pack but this would require periodic replacement of the battery. In an alternative arrangement the first monitoring unit 4 may be energised using a remote link relying upon for example inducing electrical energy by transmitting a power signal from the second monitoring unit to the first, the first monitoring unit being provided with an antenna and a detector tuned to detect the power signal, and the detector providing an output to an appropriate power supply.

In the case illustrated in Figure 1, data is transferred between the first and second monitoring units using an optical link, for example relying upon a laser or other simple optical transmission and reception systems. Other non-contact telemetry options are available however, for example infra-red systems and radio telemetry links.

In the illustrated case, the sensor array is supported on the inside surface of a side wall of a vessel. It will be appreciated that the sensor array could be mounted at any appropriate position in the process vessel, including the top wall, the bottom wall or floor, or on a support surface within the vessel, for example on an impeller blade of a stirrer assembly or a support base of a filter which does not itself form part of the containment wall.

In the illustrated case, the sheet is a laminar structure with the conducting electrodes and connections deposited on an insulating substrate. Other structures are possible, for example a filter cloth in which the cloth supports the conducting electrodes and connections on a suitably insulating substrate, or the electrodes and connections are deposited directly on the cloth e.g. by painting, or the electrodes

and/or connections are incorporated as conductive elements or threads within the cloth.

CLAIMS

1. A tomographic sensor array for mounting on a support within a vessel to enable conditions within the vessel remote from that support to be monitored, comprising a sheet carrying an array of sensors and conductors connecting the sensors to at least one output through which signals may be transmitted which are representative of conditions within the vessel.

2. A sensor array according to claim 1, wherein the sheet is laminar and the conductors are defined by conductive elements deposited on an insulating substrate.

3. A sensor array according to claim 1, wherein the sheet comprises interengaged elongate elements and the conductors are defined by conductive elements within the sheet, the conductive elements being supported by non-conductive elements within the sheet.

4. A sensor array according to claim 2 or 3, wherein the conductive elements are covered by an electrically insulating layer.

5. A sensor array according to claim 4, wherein the sensors are covered by the electrically insulating layer.

6. A sensor array according to any one of claims 1 to 5, wherein the sheet is flexible.

7. A sensor array according to any one of claims 1 to 4, wherein the sheet comprises a series of sections which are interconnected such that at least some of the conductors extend across the interconnections between the sections.

8. A system for monitoring conditions within a vessel a wall of which defines an enclosed space, comprising a sensor array in accordance with any preceding claim, wherein the sensors are distributed within the vessel, a first monitoring unit is located

within the vessel and connected to each of the sensors, and a second monitoring unit is located outside the vessel, the first monitoring unit comprising means for converting sensor output signals into transmission signals which are transmissible through the vessel wall, and the second monitoring unit comprising means for detecting the transmission signals outside the vessel walls and deriving data representative of conditions within the vessel from the transmission signals.

9. A system according to claim 8, wherein means are provided for transmitting a power signal from outside the vessel to the first monitoring unit, the first monitoring unit comprising a detector arranged to detect the power signal and a power supply energised by the detected power signal.

10. A system according to claim 9, wherein the first monitoring unit comprises an antenna and an associated detector circuit tuned to a predetermined frequency, and a power signal is transmitted at the predetermined frequency.

11. A system according to any one of claims 8 to 10, wherein the vessel incorporates a window, and the first monitoring unit is arranged to transmit optical transmission signals through the window to the second monitoring unit.

12. A system according to claim 11, wherein the first monitoring unit comprises a laser to generate the optical transmission signals.

13. A system according to claim 11 or 12, wherein the optical transmission signals are infra-red signals.

14. A system according to claim 8, 9 or 10, wherein the transmission signals are radio telemetry signals to which at least a part of the vessel wall is transparent.

15. A system for monitoring conditions within a vessel a wall of which defines an enclosed space, comprising a plurality of sensors which in use are distributed within the vessel, a first monitoring unit located within the vessel and connected to each of

the sensors, and a second monitoring unit located outside the vessel, the first monitoring unit comprising means for converting sensor output signals into transmission signals which are transmissible through the vessel wall, and the second monitoring unit comprising means for detecting the transmission signals outside the vessel walls and deriving data representative of conditions within the vessel from the transmission signals.

16. A system according to claim 15, wherein means are provided for transmitting a power signal from outside the vessel to the first monitoring unit, the first monitoring unit comprising a detector arranged to detect the power signal and a power supply energised by the detected power signal.

17. A system according to claim 16, wherein the first monitoring unit comprises an antenna and an associated detector circuit tuned to a predetermined frequency, and a power signal is transmitted at the predetermined frequency.

18. A system according to any one of claims 15 to 17, wherein the vessel incorporates a window, and the first monitoring unit is arranged to transmit optical transmission signals through the window to the second monitoring unit.

19. A system according to claim 18, wherein the first monitoring unit comprises a laser to generate the optical transmission signals.

20. A system according to claim 18 or 19, wherein the optical transmission signals are infra-red signals.

21. A system according to claim 15, 16 or 17, wherein the transmission signals are radio telemetry signals to which at least a part of the vessel wall is transparent.

22. A system according to any one of claims 15 to 21, wherein the plurality of sensors are carried by a sheet which is secured on the inside face of the vessel wall,

the sensors being connected to the first monitoring unit by conductive tracks formed on the sheet.

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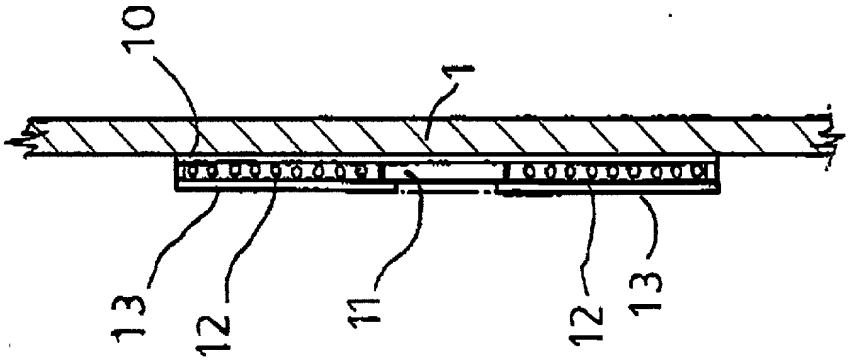

FIG. 4

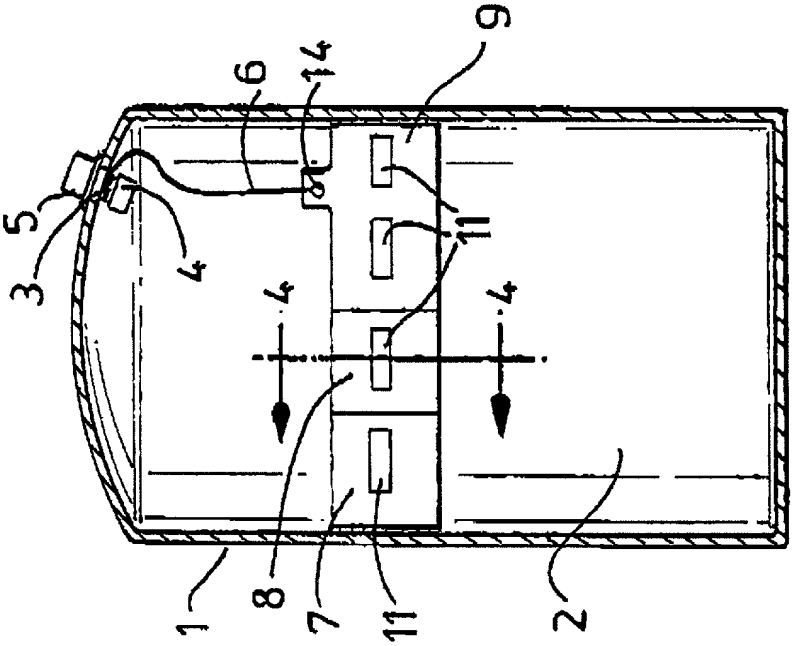

FIG. 1

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WO 00/28286

PCT/GB99/03709

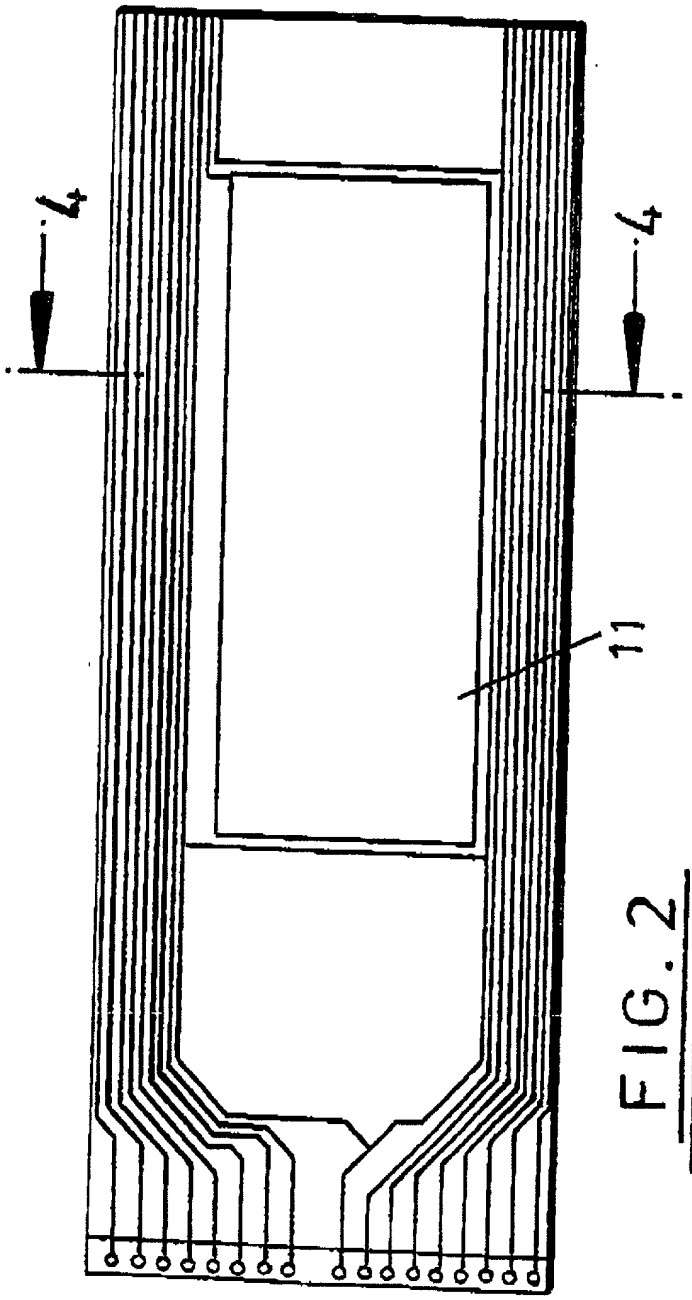

FIG. 2

09/831665

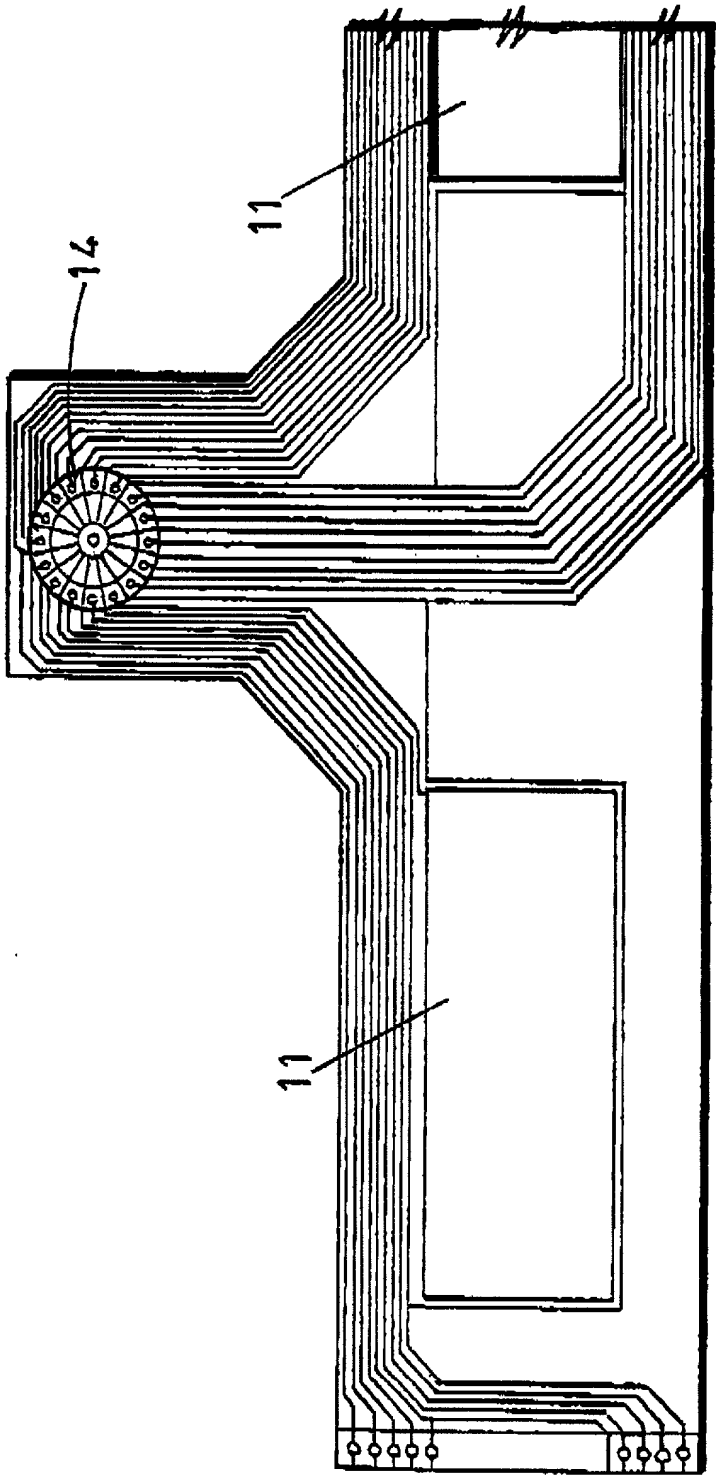

FIG. 3

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

Attorney Docket Number	7418-2
First Named Inventor	Brian Hoyle

☐ Declaration submitted with initial Filing

☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16(e)) required)

COMPLETE IF KNOWN	
Application No.	09/831,665
Filing Date	
Group Art Unit	
Examiner's Name	

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

MONITORING SYSTEM

the specification of which
(check one)
is attached hereto.

☐ Was filed on November 10, 1999 as United States Application No. or

PCT International Application No. PCT/GB99/03709

And was amended on _____(if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) or 365(b) of any foreign pplication(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at east one country other than the United States of America, listed below and have also identified below, by hecking the box, any foreign application for patent or inventor's certificate having a filing date before that of the pplication on which priority is claimed:

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YY)	Priority Not Claimed	Certified Copy Attached? Yes	No
PCT/GB99/03709	PCT	11/10/1999		☐	☐
GB9824689.5	GB	11/11/1998		☐	☐

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed elow and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior nited States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I cknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, 1.56 which occurred between the filing date of the prior application and the national or PCT international filing ate of this application:

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (If applicable)

☐ **Additional US or PCT International application numbers are listed on a supplement priority data sheet PTO/SB/02B attached hereto.**

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and transact all business in the atent and Trademark Office connected therewith:

☐ Customer Number →

OR

X Registered practioner(s) name/registration number listed below.

Place Customer Number Bar Code Label Here

Name	Registration Number	Name	Registration Number
Thomas Q. Henry	28,309		

X Additional registered practioner(s) named on supplemental Registered Practioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to : ☐ Customer Number Bar Code Label *OR* X Correspondence address below

Name	Thomas Q. Henry					
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Address	111 Monument Circle, Bank One Tower Suite 3700					
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Country	USA	Telephone	317/ 634-3456		Fax	317-637-7561

I hereby declare that all statements made herein of my own knowledge are true and that all statements made n information and belief are believed to be true; and further that these statements were made with the nowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, nder Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize he validity of the application or any patent issued thereon.

Full name of sole or first inventor:

Given Name (first and middle, if any)	**Brian Stewart**	**Family Name or Surname**	**Hoyle**
nventor's Signature:		**Date of Signature:**	23 JULY 2001
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Full name of additional joint inventor, if any:			
Given Name (first and middle, if any)		Family Name or Surname	
Inventor's Signature:		Date of Signature:	
Residence: (City, State, Country)			
Citizenship:			
Post Office Address:			

e a Plus sign (+) inside this box →

WENMM SB/02C (3-97)

DECLARATION	Registered Practitioner Information (Supplemental Sheet)

Name	Registration Number	Name	Registration Number
Harold R. Woodard	16,214		
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John C. McNett	25,533		
Thomas Q. Henry	28,309		
James M. Durlacher	28,840		
Charles R. Reeves	28,750		
Vincent O. Wagner	29,596		
Steve Zlatos	30,123		
Spiro Bereveskos	30,821		
William F. Bahret	31,087		
Clifford W. Browning	32,201		
R. Randall Frisk	32,221		
Daniel J. Lueders	32,581		
Kenneth A. Gandy	33,386		
Timothy N. Thomas	35,714		
Kerry P. Sisselman	37,237		
Kurt N. Jones	37,996		
John H. Allie	39,088		
Holiday W. Banta	40,311		
Troy J. Cole	35,102		
L. Scott Paynter	39,797		
J. Andrew Lowes	40,706		
Charles J. Meyer	41,996		
Matthew R. Schantz	40,800		
Gregory B. Coy	40,967		
Lisa A. Hiday	40,036		
John V. Daniluck	40,581		
Christopher A. Brown	41,642		
C. John Brannon	44,557		
Jason J. Schwartz	43,910		
Arthur J. Usher IV	41,359		
Douglas A. Collier	43,556		
Brad A. Schepers	45,431		
Scott J. Stevens	29,446		
James B. Myers	42,021		
John M. Bradshaw	46,573		
C. Amy Ng Smith	42,931		
Charles P. Schmal	45,082		
Edward E. Sowers	36,015		

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